

**TRANSLATION**

**PATENT COOPERATION TREATY**

**PCT**

**INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY**

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>PKHF05004</b>	<b>FOR FURTHER ACTION</b>		See Form PCT/IPEA/416
International application No. <b>PCT/JP2005/000420</b>	International filing date ( <i>day/month/year</i> ) <b>14.01.2005</b>	Priority date ( <i>day/month/year</i> ) <b>18.02.2004</b>	
International Patent Classification (IPC) or national classification and IPC <b>H01L33/00 (2006.01) , C23C14/08 (2006.01) , C30B29/16 (2006.01)</b>			
Applicant <b>WASEDA UNIVERSITY</b>			

<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of <b>6</b> sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input type="checkbox"/> (<i>sent to the applicant and to the International Bureau</i>) a total of _____ sheets, as follows:</p> <p><input type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) _____, containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p> <p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the report</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>
---

Date of submission of the demand	Date of completion of this report
Name and mailing address of the IPEA/JP	Authorized officer
Facsimile No.	Telephone No.

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/JP2005/000420

## Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
  - This report is based on translations from the original language into the following language \_\_\_\_\_, which is the language of a translation furnished for the purposes of:
    - international search (Rule 12.3 and 23.1(b))
    - publication of the international application (Rule 12.4)
    - international preliminary examination (Rule 55.2 and/or 55.3)
2. With regard to the **elements** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):
  - the international application as originally filed/furnished
  - the description:
 

pages \_\_\_\_\_ as originally filed/furnished

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
  - the claims:
 

nos. \_\_\_\_\_ as originally filed/furnished

nos.\* \_\_\_\_\_ as amended (together with any statement) under Article 19

nos.\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

nos.\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
  - the drawings:
 

sheets \_\_\_\_\_ as originally filed/furnished

sheets\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_

sheets\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
  - a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.
3.  The amendments have resulted in the cancellation of:
  - the description, pages \_\_\_\_\_
  - the claims, nos. \_\_\_\_\_
  - the drawings, sheets/figs \_\_\_\_\_
  - the sequence listing (*specify*): \_\_\_\_\_
  - any table(s) related to sequence listing (*specify*): \_\_\_\_\_
4.  This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
  - the description, pages \_\_\_\_\_
  - the claims, nos. \_\_\_\_\_
  - the drawings, sheets/figs \_\_\_\_\_
  - the sequence listing (*specify*): \_\_\_\_\_
  - any table(s) related to sequence listing (*specify*): \_\_\_\_\_

\* If item 4 applies, some or all of those sheets may be marked "superseded."

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/JP2005/000420

**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Claims _____	YES
	Claims 1-8	NO
Inventive step (IS)	Claims _____	YES
	Claims 1-8	NO
Industrial applicability (IA)	Claims 1-8	YES
	Claims _____	NO

**2. Citations and explanations (Rule 70.7)**

Document 1: T. HARWIG et al., "Electrical properties of  $\beta$ -Ga<sub>2</sub>O<sub>3</sub> single crystals II," Journal of Solid State Chemistry, 15 January 1978, Vol. 23, pages 205 to 211

Document 2: T. HARWIG et al., "Electrical properties of  $\beta$ -Ga<sub>2</sub>O<sub>3</sub> single crystals," Solid State Communications, 1976, Vol. 18, pages 1223 to 1225

The inventions set forth in claims 1 to 4 and 6 to 8 lack novelty in the light of documents 1 and 2 cited in the international search report. Documents 1 and 2 both indicate that doping Ga<sub>2</sub>O<sub>3</sub> single crystals with Zr (a group IV element) will cause a reduction in the resistance of the Ga<sub>2</sub>O<sub>3</sub> single crystals, and that doping Ga<sub>2</sub>O<sub>3</sub> single crystals with Mg (a group II element) will cause the resistance of the Ga<sub>2</sub>O<sub>3</sub> single crystals to increase to at least  $1 \times 10^3$   $\Omega$ cm or higher. Furthermore, the documents in question also indicate that heating Zr-doped Ga<sub>2</sub>O<sub>3</sub> single crystals will cause the resistance of the Ga<sub>2</sub>O<sub>3</sub> single crystals to decrease to  $1 \times 10^2$   $\Omega$ cm or lower (in particular, refer to document 1, fig. 1).

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/JP2005/000420**Box No. V** **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

Document 3: N. UEDA et al., "Synthesis and control of conductivity of ultraviolet transmitting  $\beta$ - $\text{Ga}_2\text{O}_3$  single crystals," Applied Physics Letters, 30 June 1997, Vol. 70, Issue 26, pages 3561 to 3563

The inventions set forth in claims 1 to 5 lack novelty in the light of document 3 cited in the international search report. Document 3 indicates that doping  $\text{Ga}_2\text{O}_3$  single crystals with Sn (a group IV element) will make it possible to control the conductivity of the  $\text{Ga}_2\text{O}_3$  single crystals within a range of  $10^{-9} \Omega^{-1}\text{cm}^{-1}$  to  $38 \Omega^{-1}\text{cm}^{-1}$ ; furthermore, document 3 also presents examples and the like wherein a configuration with a carrier concentration of  $5 \times 10^{-18}\text{cm}^{-3}$  exhibited a conductivity of approximately  $30 \Omega^{-1}\text{cm}^{-1}$  to  $38 \Omega^{-1}\text{cm}^{-1}$  (in particular, refer to document 3, page 3562, right column and fig. 2)

Document 4: Y. TOMM et al., "Floating zone growth of  $\beta$ - $\text{Ga}_2\text{O}_3$ : A new window material for optoelectronic device applications," Solar Energy Materials & Solar Cells, February 2001, Vol. 66, pages 369 to 374

The inventions set forth in claims 1 to 3 lack novelty in the light of document 4 cited in the international search report. Document 4 indicates that doping  $\text{Ga}_2\text{O}_3$  single crystals with Ge or Ti will make it possible to control the conductivity of the  $\text{Ga}_2\text{O}_3$  single crystals.

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/JP2005/000420**Box No. V** Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Document 5: J. FRANK et al., "Electrical doping of gas-sensitive, semiconducting Ga<sub>2</sub>O<sub>3</sub> thin films," Sensors and Actuators B: Chemical, August 1996, Vol. 34, pages 373 to 377

The inventions set forth in claims 1 to 3 and 6 to 7 lack novelty in the light of document 5 cited in the international search report. Document 5 indicates that doping Ga<sub>2</sub>O<sub>3</sub> single crystals with Zr, Mg or Ti will make it possible to control the conductivity of the Ga<sub>2</sub>O<sub>3</sub> single crystals.

Document 6: US 2003/0107098 A1 (OTA et al.), 12 June 2003, abstract; paragraphs [0046] and [0055] to [0056]; and table 1

The inventions set forth in claims 1 to 3 lack novelty in the light of document 6 cited in the international search report. Document 6 indicates that doping Ga<sub>2</sub>O<sub>3</sub> single crystals with Sn, Ge, Si, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, Ti or the like will make it possible to control the conductivity of the Ga<sub>2</sub>O<sub>3</sub> single crystals.

Document 7: US 2004/000708 A1 (ICHINOSE et al.), 15 January 2004, paragraphs [0038] to [0044]

The inventions set forth in claims 1 to 8 do not involve an inventive step in the light of documents 1 to 7 cited in the international search report. Document 7 indicates that adding trace amounts of Cu, Ag, Zn, Cd, Al, In, Si, Ge, Sn or the like to Ga<sub>2</sub>O<sub>3</sub> single crystals will make it possible to control the lattice constant

**INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY**International application No.  
PCT/JP2005/000420**Box No. V** **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

and/or the band gap of the Ga<sub>2</sub>O<sub>3</sub> single crystals. In addition, based on the disclosures in documents 1 to 6 it would have been clear to a person skilled in the art that adding the aforementioned elements to Ga<sub>2</sub>O<sub>3</sub> single crystals will also make it possible to control the conductivity of the Ga<sub>2</sub>O<sub>3</sub> single crystals. Such being the case, the conductivity and the carrier concentration of the Ga<sub>2</sub>O<sub>3</sub> single crystals are considered to be design matters that a person skilled in the art could configure in an appropriate manner by controlling the concentration of the dopant(s) and the like.